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MUNICIPAL WATER ISSUES IN CANADA

Stephanie Meakin
Science and Technology Division

April 1993

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CANADIAN MUNICIPAL WATER ISSUES

INTRODUCTION

Canadians are the world's second largest per capita users of water[1] with the average Canadian household using 360 litres of water per day.[2] Water is used in all sectors of our society -- industry, agriculture, transportation, energy, recreation -- as well as by municipalities and it must undergo some degree of treatment before being used and returned to the water system. This paper examines issues relating to municipal water use: water consumption, wastewater treatment, water pricing and water security.

Canada has roughly 9% of the world's annual renewable freshwater supply;[3] however, over half of the water run-off in Canada flows north, away from the centres of population and industry, leaving scarce supplies in some southern regions. In developed areas, pollution has significantly impaired the natural quality of the resource.[4] Increasing urbanization, together with inadequate infrastructures for water treatment, is leading to concerns about the quality of the water we consume and the deterioration of the receiving waters of municipal treatment facilities. The cost of collecting, storing and distributing water is also

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(1) The United States has the largest per capita consumption of water in the world.

(2) Environment Canada, *The State of Canada's Environment*, Ottawa, Chapter 3:1, 1991.

(3) Approximately 97% of the 1.5 x 10^9km^3 water estimated to be on earth is liquid salt water in the oceans and seas. Of the 3% of fresh water, approximately 75% exists in solid form in the polar ice caps and in the glaciers. At least 90% of the less than 1% remaining is groundwater, and the remainder is fresh surface water, mainly in lakes and rivers.

(4) Peter Pearse and Donald Tate, "Economic Instruments for Sustainable Development of Water Resources," in *Perspectives on Sustainable Development in Water Management: Towards Agreement in the Fraser River Basin*, Anthony Dorcey, ed., Westwater Research Centre, 1991, p. 431.

increasing. Approximately 57% of Canadians, compared with 74% of Americans, 86.5% of Germans, and 99% of Swedes, are served by wastewater treatment plants.

Concern over the quality of water for consumption and the decreasing quality of receiving waters has led some government departments to look at how municipal treatment facilities are complying with the *Fisheries Act*. The municipal use and treatment of water are the focus of this document.

WATER AS A RESOURCE

> Achieving water balance will not be easy. The policies, laws, and practices that shape water use today rarely promote all three basic tenets of sustainable resource use - efficiency, equity, and ecological integrity.[(5)]

Water is a basic necessity of life; it is not only essential for our survival, but it contributes immeasurably to the quality of our lives. It is used in agriculture, industry, transportation, energy production, and manufacturing; for municipalities, it is a vehicle for removing waste and sustaining life. The way we use water, the amount we use, and our methods of preserving it are very important for the sustainability of this resource. Unlike many other vital resources, water has no substitute in most of the activities and processes where it is needed in society and in nature. Yet, despite its importance and increasing scarcity, water is seldom considered to be a resource like the others.[(6)]

All the fresh water in the world's lakes, streams and rivers represents less than 0.01% of the earth's total water store.[(7)] Some uses remove water from the natural cycle and

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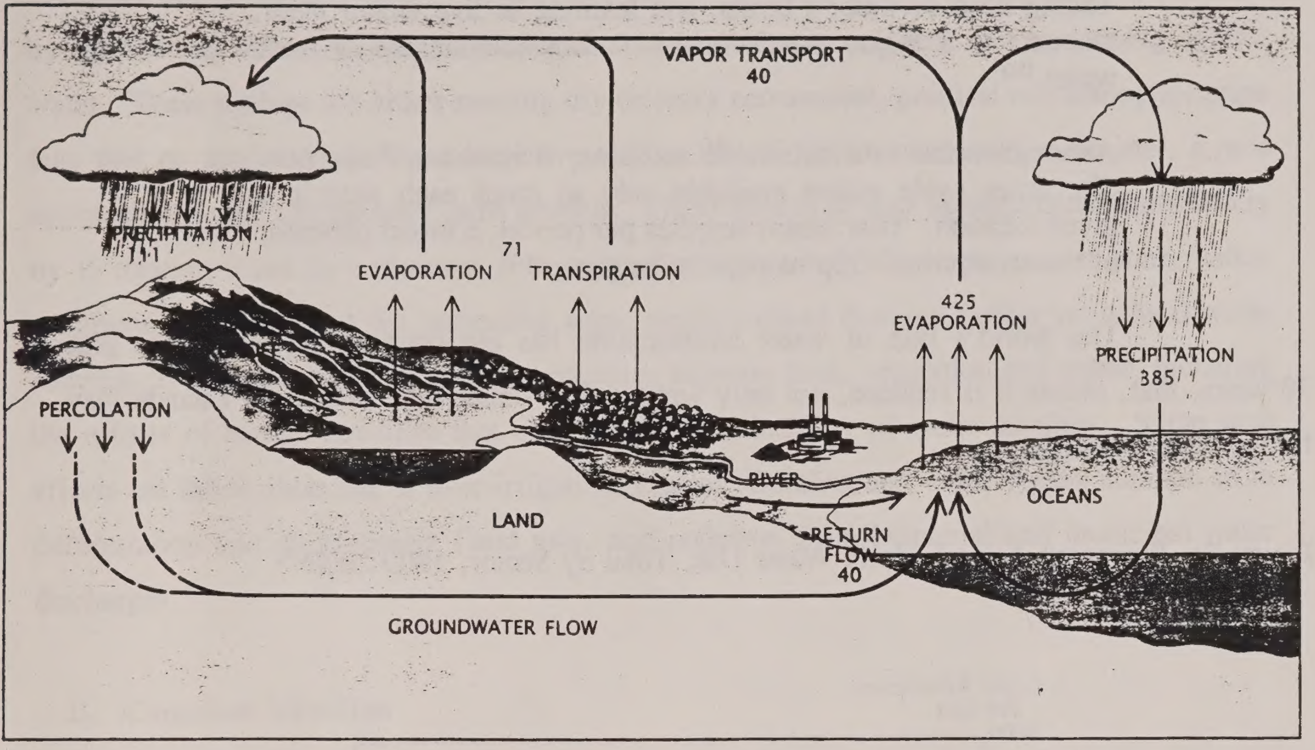
(5) Postel Sandra, *Last Oasis*, Linda Starke Series Editor, W.W. Norton and Co., New York, 1992, p. 22.

(6) Jan Lundqvist, "Water Scarcity in Abundance: Management and Policy Challenges," *Ecodecision*, September 1992, p. 41-43.

(7) J.W. Maurits la Riviere, "Threats to the World's Water," *Scientific American*, September 1989, p. 80-84.

RECYCLED RECYCLÉ

Figure 1: Global Water Cycle



The global water cycle has three major pathways: precipitation, evaporation and vapour transport. Water precipitates from the sky as rain or snow, most of which falls into the oceans; it returns to the atmosphere by evaporation. Some flows from the land to the sea as runoff or groundwater; in the other direction water vapour is carried by atmospheric currents from the sea to the land.[8]

others lower its quality before returning it.[9] The estimated amount of water available annually for human exploitation is 9,000 km^3, in principle enough to sustain 20 billion people.[10] The problem is that the available water is not evenly distributed, so that there are water-scarce countries and water-rich countries. A citizen of the United States uses 70 times more water than the average citizen of Ghana. Sustainable supplies of this resource can be achieved only by having a water management strategy and direction in management and policy decisions.

(8) *Ibid.*, p. 82.

(9) Environment Canada, Conservation and Protection, *Fact Sheet 4: Water Works*, 1990.

(10) Maurits la Riviere (1989), p. 80-84.

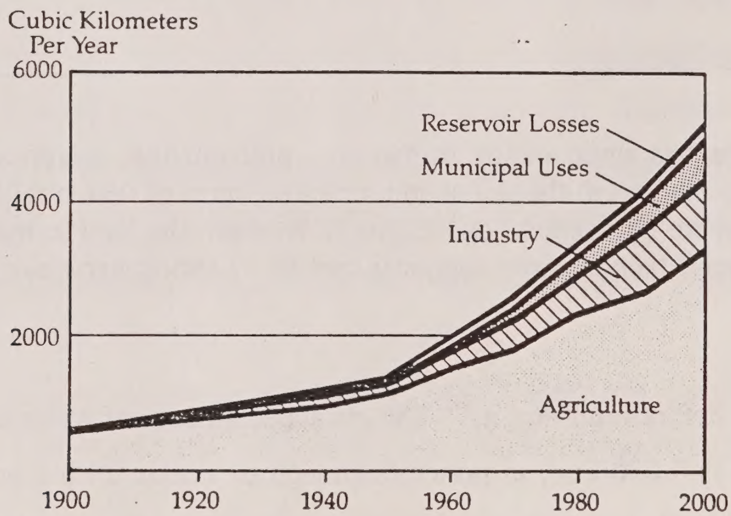
A. World Situation

> Taking heed of water's limits, and learning to live within them, amounts to a major transformation in our relationship to fresh water.[11]

> Although water is a renewable resource, it is also a finite one. The water cycle makes available only so much each year in a given location. That means supplies per person, a broad indicator of water security, drop as population grows.[12]

The world's rate of water consumption has escalated so rapidly in the past 30 years, that, unless it is reduced, not only water-scarce countries,[13] but even Canada may face a water shortage.

Figure 2: Estimated Annual World Water Use, Total by Sector, 1900-2000[14]



(11) Postel, *Last Oasis* (1992), p. 23.

(12) *Ibid.*, p. 28.

(13) Hydrologists designate water-scarce countries as those with annual supplies of less than 1,000 m^3 per person; today, 26 countries (232 million people) fall into this category.

(14) Postel, *Last Oasis* (1992), p. 40.

Global water use has more than tripled since the 1950s and now stands at an estimated 4,340 km^3 per year.[15] Water planners have responded to these increasing demands by introducing water projects, including dams and diversion projects, and by tapping aquifer water. These options are either running dry or carry economical, political and ecological price tags that no longer make them attractive options.[16] If human needs are to be met, a new approach to water management must develop. Three directions may be undertaken immediately by 1) treating water as a resource and paying the real cost; 2) developing water conservation programs that help meet the increasing water needs without drawing further on natural water sources; 3) addressing the complex interactions between land, vegetation and water, including the effects of human activities that decrease the sustainability of water supplies. Some such effects are salinization due to over-irrigation, erosion, flooding and water system siltation from deforestation and development (land use), and pollution from industrial and municipal water discharges.

B. Canadian Situation

Canadian water resources are overused; residential water use is two to three times that of some European countries. Our overuse costs billions of dollars in supply and wastewater infrastructure. Four areas present concern: first, we do relatively little water recycling compared to other nations and large amounts of public capital are spent to develop irrigation systems;[17] second, water planners often tend to treat claims on our water as "requirements" that must be met rather than "demands" to be managed;[18] third, research into water issues

---

(15) Sandra Postel, *Water Scarcity, Environment, Science and Technology*, Vol. 26, No. 12, p. 2332, 1992.

(16) There are 36,000 large dams around the world to control floods, provide hydroelectric power, irrigation, industrial and municipal or consumptive supplies.

(17) Donald M. Tate, *Technological Change and the Water Industry: Some Observations*, 1991 Canadian Water Resources Association Meeting.

(18) *Ibid.*

tends to be underfunded through the private sector; last, and most important, is the deterioration of the quality of the Canadian water supply.

WATER USES

A. General

Water supply and wastewater systems are essential to the social and economic functioning of our modern community, not only from the point of view of health, but to service a large sector of our commercial and industrial activity, and to protect against fire and flooding.[19]

Water use is broadly divided into two categories: instream use and withdrawal use. "Instream use" includes any use of the water in its natural setting; fishing, boating, shipping and hydro-electricity are examples. "Withdrawal uses" include those that remove the water for use on land. Water is withdrawn from a stream, lake, river, groundwater supply or the ocean, and piped, channelled or transported to the site of use. After use, the water is re-collected and returned to the groundwater or water system. Examples include household and municipal uses, industrial use, thermal and nuclear power generation, irrigation, and livestock watering.[20] Both types of water use affect the quality of the source water. Instream use leads to pollution by ship oil and diesel, while hydro-electric facilities affect the natural routes of water systems and reservoirs cause evaporation and flooding as well as natural mineral and element leachate. Withdrawal use often returns less water than it removed[21] and the water it returns is usually of a lower quality. The largest consumptive use of water is crop irrigation, followed by evaporation from large hydro reservoirs.[22]

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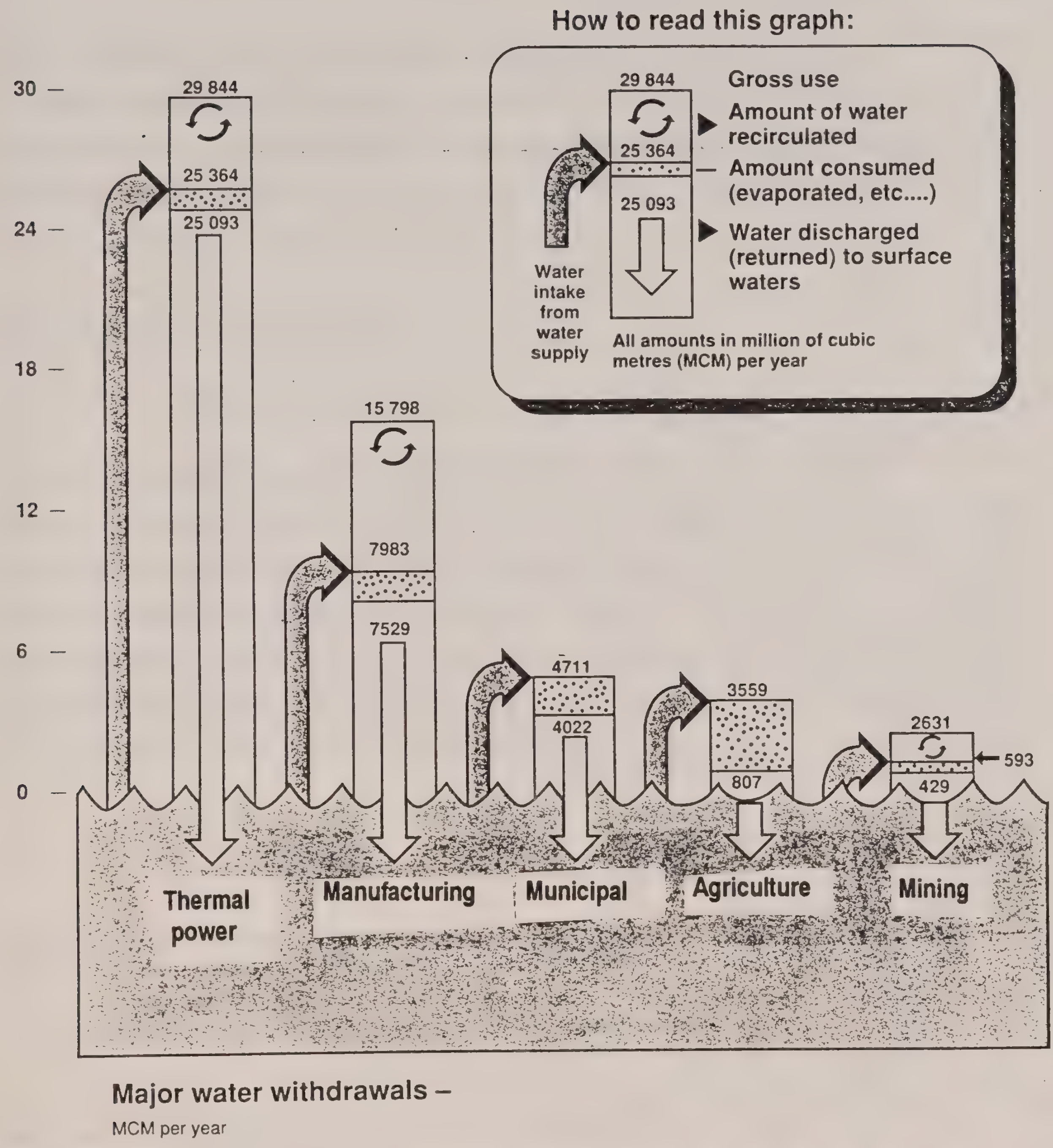
(19) J.W. MacLaren, *Municipal Waterworks and Wastewater Systems*, Inquiry on the Federal Water Policy, January 1985.

(20) *Ibid.*

(21) Water consumption is the difference between the amount of water taken for withdrawal use and the amount of water returned.

(22) Environment Canada, Conservation and Protection, *Fact Sheet 4: Water Works*, 1990.

Figure 3: Water Use in Canada, 1986[23]



(23) Environment Canada, Conservation and Protection, *Fact Sheet 4: Water Works*, 1990.

B. Drinking Water

> ...primary health care includes at least an adequate supply of safe water and basic sanitation.[24]

The quality of water desired varies, depending on the intended use. The importance of the quality of water destined for human consumption is not a recent discovery. In his writings on public health, Hippocrates (460-377 BC) placed particular stress on the essential role of water in maintaining health, even recommending that rainwater be filtered and boiled before consumption. It was not until 1854 that the English doctor John Snow, while conducting epidemiological studies on cholera, proved beyond a doubt that water could transport infectious agents. There was no particular move to water treatment in Canada until the typhoid epidemics in the early 1900s. Fredericton, New Brunswick, lays claim to having had the first water filtration plant in Canada.[25]

The quality of water for drinking and bathing is regulated by guidelines stringent enough to protect human health.[26] Lack of such guidelines leads to a number of health problems. It is estimated that contaminated water and poor sanitation cause 30,000 deaths around the world every day.[27] Statistics reveal that many Canadians, particularly native people living in smaller communities in remote areas of Canada, have drinking water quality and sanitation levels considerably lower than the national average and in some instances below the objectives of the World Health Organization.

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(24) Declaration of Alma-Alta (1978) arose out of the efforts made at the 1978 Conference on Primary Health Care held in Alma-Alta, USSR to achieve primary health care for all.

(25) Steve Bonk, "Emerging Considerations for Safe Drinking Water in Canada," Canadian Society for Civil Engineering - Environmental Engineering Division, 1992.

(26) In 1968, Health and Welfare Canada undertook primary responsibility for producing Canada's first national water quality document. In 1986, a Federal-Provincial Sub-Committee on Drinking Water was created to revise and update the document, now named *Guidelines for Canadian Drinking Water Quality*. These Guidelines were updated and revised in 1989.

(27) Environment Canada, Conservation and Protection, *Fact Sheet 3: Clean Water - Life Depends on It!*, 1990.

In most parts of Canada, there are plentiful sources of good drinking water. Water-related illnesses such as typhoid fever, cholera, dysentery, giardiasis, and hepatitis are almost unknown in this country, whereas 80% of the diseases in the third world are water-related. Of serious concern in Canada are toxic chemicals entering our water systems from many sources, including industry, agriculture and the home. Little is known about the effects of these substances on human health; often they do not become noticeable for many years, and they are difficult to distinguish from the effects of other factors.[28] Much remains to be done to control toxic chemical pollution at its source.

THE COST OF CLEAN WATER

Water is free; the cost of water is incurred in its treatment, pumping, delivery and pressure, and in treatment of waste. "Canadians should be paying more for the water they use," according to Environment Minister Jean Charest.[29] In Canada, the price of water varies greatly from province to province and even within provinces. Water rate schedules[30] across the country are extremely diverse, each municipality having its own unique set of rates. In the 470 municipalities included in the 1987 Environment Canada study,[31] over 1,100 individual rate schedules were found. There are four main types: flat rate (the most common), constant unit rate, declining block rate and increasing block rate.

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(28) The quality of water can be analyzed by sophisticated analytical laboratory equipment, which can detect contaminants to parts per billion.

(29) Ruth Teichroeb, "Raise Water Prices to Float Repairs, Charest Says," *Winnipeg Free Press*, 7 February 1993.

(30) Water rate schedules cover water use as well as sewer charges.

(31) D.M. Tate, *Municipal Water Rates in Canada, 1986 - Current Practices and Prices*, Social Science Series No. 21, Inland Waters Directorate Water Planning and Management Branch, Ottawa, Ontario, 1989, p. v.

Table 1: Types of Rate Structures [32]

Type	Description	Conservation Potential
Flat rates	Customer pays a fixed rate per time period for unlimited access to public water supply	None; encourages excessive use
Declining block rates	Water use is divided into two or more volume ranges or blocks. The rates decline progressively for water use in the larger blocks.	Progressively decreasing as water use increases
Constant unit rates	Charges per unit of water use (e.g. cubic meter) are constant through the range of usage.	Moderate to good
Increasing block rates	Similar to decreasing block rates except that rates increase progressively through the range of usage.	Progressively increasing as water use increases

Almost all rate schedules offer either no financial incentive (e.g., flat rates) or decreasing incentives (e.g., declining block rates) to minimize water use and the costs of the water systems. As a result, over 70% of these schedules do nothing to discourage excessive water demand.[33][34]

Water as a resource is undervalued. Residential water servicing costs between \$0.50-\$0.60 per cubic metre.[35] In Canada, 33% of the public water supplies are on a flat-rate basis; in other words, excessive use is cost-free to the consumer. Industrial water costs are

(32) D.M. Tate, "Water Demand Management and Sustainable Development," Canadian Society of Environmental Biologists, *Newsletter/Bulletin*, Vol. 48(3), 1991, p. 15.

(33) D.M. Tate, "Municipal Water Rates in Canada, 1986 - Current Practices and Prices" (1989).

(34) For a detailed approach to rate setting, please see, "A New Approach to Rate Setting: Municipal Water and Wastewater Rate Manual," Canadian Water and Wastewater Association and Rawson Academy of Aquatic Science in Association with Environment Canada, January 1993.

(35) Tate (1991), p. 4.

less than half the cost of supply. Irrigation water is subsidized to 85% of the cost of developing the systems.[36] Canadian water pricing does not on the whole support a sustainable use and supply.

Many existing treatment facilities are becoming increasingly inadequate: water mains, sewers and treatment plants are aging and gradually deteriorating, with some systems in older cities being over 100 years old.[37] It is estimated that $10 billion is needed for improvements to municipal sewer and water systems in this country. One of the reasons that this money is not available is that Canadians are not paying the true cost of their water.

The argument is that the water rate structure must be revised to benefit conservation. In Canada, 37% of the people pay a flat rate for water, regardless of consumption, while 34% of municipalities are on "declining block rates" for water pricing, whereby costs decrease with each additional unit used. To maintain a sustainable supply of fresh water, we need a more realistic pricing policy that would encourage conservation and reduce the need to disrupt natural systems to find alternative water sources. Education for appropriate use of municipal sewage systems reduces the amounts of toxins deposited and thus decreases the costs of treatment, repair and maintenance. The 1987 Federal Water Policy called for realistic water pricing as a central measure to encourage both water conservation and the user-pay philosophy for valuing water resources. It argued in favour of water prices that would reflect the true costs of supply and treatment and provide enough revenue to maintain and upgrade infrastructure. It called for universal metering and realistic rate schedules.[38] It is up to the decision-makers in local communities and elsewhere to determine how the value of water should be reflected in prices, subsidies, free allocations and so on.

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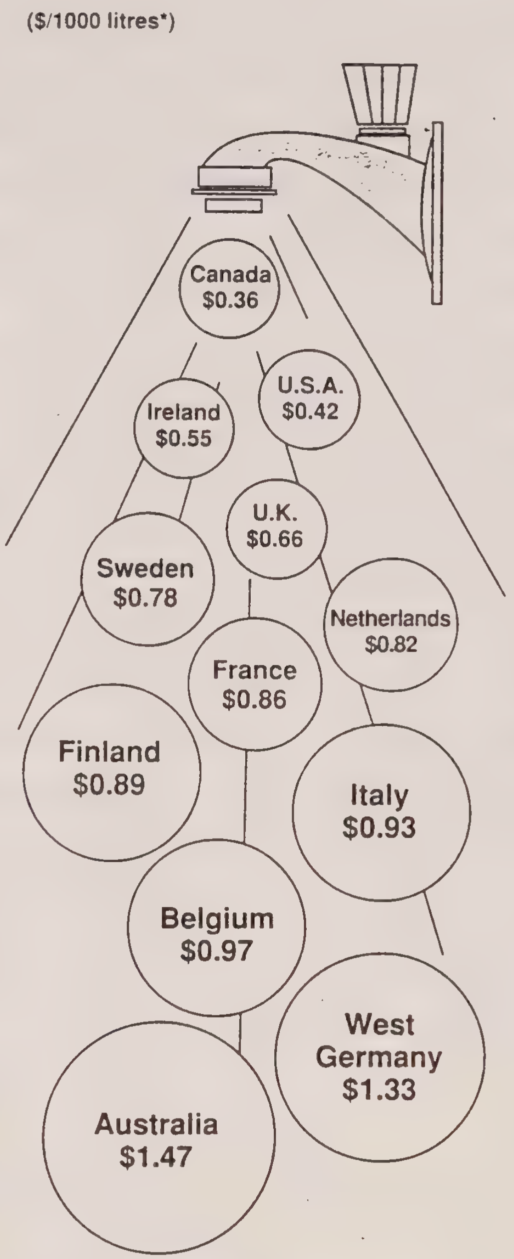
(36) Two-thirds of Canadian water use is accounted for by agriculture.

(37) Government of Canada, *The State of Canada's Environment*, 1991, p. 13-14.

(38) "The Conservation Retrofit will Save Taxpayers $400,000 at a Cost of $250,000," *Government Business*, December 1992, p. 25.

Figure 4: Typical Municipal Water Prices[39]



* All amounts are 1989 Canadian dollars. In most countries, these prices are increasing from year to year. These figures do not include the cost of waste treatment.

(39) Environment Canada, Conservation and Protection, *Fact Sheet 4: Water Works*, 1990.

POLITICS OF WATER

Heightened environmental awareness has created a great deal of interest in protecting our water supply, both surface and underground. To that end, nations are drafting tougher laws to protect this resource, and even international trade negotiations are beginning to contemplate restrictions on possible environmental damage. A large problem with legislation protecting water is the difficulty of enforcing it over borders. As well, sources or locations of contamination in other countries are difficult to assess and prosecute.

A. Canada

Canada has a great number of policies and legislation at all levels of government dealing with the quality of water. Legislation and policies to protect Canada's liquid assets include Canadian Water Quality Guidelines, established by Health and Welfare Canada; the 1987 Federal Water Policy,[40] Canada's national strategy for managing water resources; the *Canadian Environmental Protection Act* (1988); the Green Plan; *Drinking Water Safety Act* (1991); and the *Fisheries Act*.

Legislation of water and its subsequent contamination by human use is a complicated jurisdictional issue. The federal Department of Fisheries and Oceans has primary responsibility for the administration of the *Fisheries Act* [41] provisions that provide for the protection and conservation of fish and fish habitat. Environment Canada has been assigned the responsibility of enforcement and administration of the *Fisheries Act* provisions dealing with the

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(40) The Federal Water Policy is a statement of the federal government's philosophy and goals for the nation's freshwater resources and proposed ways of achieving them. It recognizes that water is Canada's most undervalued and neglected natural resource. In no part of Canada is freshwater of sufficient quality and quantity that it can continue to be overused and abused. The underlying philosophy of the policy is that Canadians must start viewing water both as a key to environmental health and as a scarce commodity with real value that must be managed accordingly.

(41) Under the *Constitution Act*, the federal government has exclusive legislative authority to manage and regulate Canada's sea coast and inland fisheries. The *Fisheries Act*, first passed in Parliament in 1886, is the federal statute promulgated pursuant to this constitutional authority. See Department of Fisheries and Oceans, "*Fisheries Act* Habitat Protection and Pollution Prevention Provisions Compliance Policy," Draft, April 1992.

deposit of deleterious substances (section 36(3) of the *Fisheries Act*) into water frequented by fish.[42] The provinces and territories also have jurisdictional power. A joint and co-operative management approach with the provinces is sought by the federal government since, under the *Constitution Act*, the provinces exercise direct control over many aspects of water management. In view of the jurisdictional situation in Canada, responsibility for municipal waste treatment within provincial territory rests mainly with the provincial governments, who exercise this authority rigorously.[43] In the municipal area, the federal government role varies:

- in some areas, the federal government has jurisdiction: Indian reserves, national parks, etc.;

- in areas of primary provincial jurisdiction, the federal government has the responsibility to ensure its own facilities meet accepted provincial standards;

- in shared jurisdiction (international and interprovincial waters), the federal government has a limited role, depending on federal-provincial agreements.[44]

B. Other Countries

> The national security of Egypt is in the hands of the eight other African countries in the Nile basin.[45]

Nearly half the world's land is fed by water basins that cross national borders and well over 200 countries share important rivers and lakes.[46] Water has become a strategic

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(42) A municipality with inadequately treated municipal wastes may be in violation of the federal *Fisheries Act*. Since Environment Canada has administrative responsibility for section 33 of the Act (prohibition of deleterious substances), enforcement officers could charge such a municipality. D. Tate, "The Federal Policy with Regard to Municipal Infrastructure and Effluent: Notes Towards an Updated Strategy (III)," Draft, 1992.

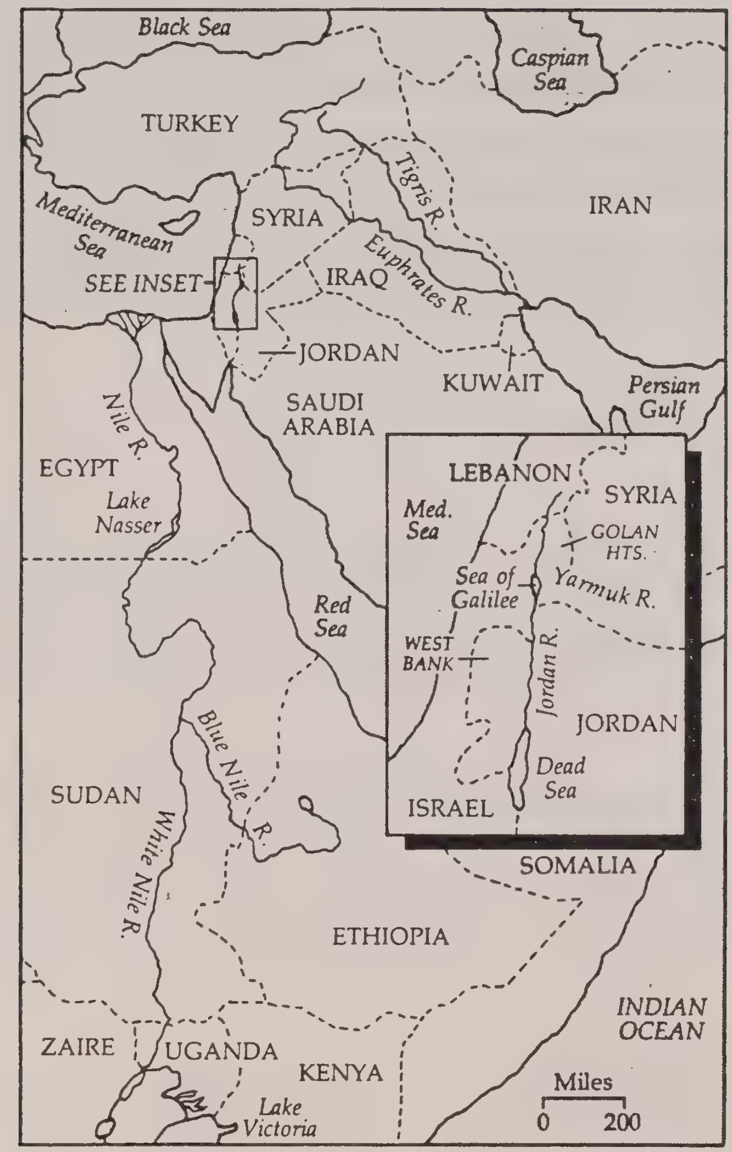
(43) *Ibid.*

(44) *Ibid.*

(45) Boutros Boutros-Gali, Address before the United Congress, 1989.

(46) Bronwen Maddox, "World's Fresh Water Tap in Peril," *Financial Post*, 19 March 1993.

Figure 5: Middle East Water Basins



asset in countries of water dependency. Nearly 40% of the world's people live in river basins shared by countries. India and Bangladesh both border the Ganges River; Mexico and the United States share the Colorado River; the Danube is shared by Czechoslovakia and Hungary; Thailand and Vietnam share the Mekong.[47] In Africa, 57 river and lake basins are shared by at least two nations. In the Middle East, however, political landscapes, as well as the economic future, are being shaped by water shortages.[48]

> All told, the politics of water exhibit far more friction and strife than harmony and teamwork.[49]

Economic and social stability depend on an assured water supply, and more nations will begin to perceive water as an issue of national security.

TREATING WATER POLLUTION

A substantial portion of the wastes entering our water come from point sources such as industrial discharge pipes and municipal sewer outlets,[50] or indirectly via leachate, or pollutants carried in the atmosphere. Industrial wastewaters must meet guidelines in provincial and federal legislation, but it has been reported that as many as 54% of the 170 direct dischargers in Ontario exceed these monthly pollution limits.[51] Many industries use municipal sewers and treatment facilities as their primary (or only) method of wastewater abatement and this often overtakes municipal treatment facilities. This is one of the most serious problems facing the municipal water industry.[52] Municipal bylaws may limit the substances

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(47) Postel, *Last Oasis* (1992), p. 74.

(48) *Ibid.*

(49) *Ibid.*

(50) Government of Canada, *The State of Canada's Environment*, Chapter 14:9, 1991.

(51) *Ibid.*

(52) Tate (1992), p. 1.

industries can put into the sewer system, but this is usually to protect the sewage system rather than to control the release of environmentally harmful materials.[53] Such disposal poses a serious threat, even if there is a high degree of municipal sewage treatment. Municipal facilities may not treat toxic industrial contaminants and it is almost impossible to police sewage discharges.

Municipal water supplies are also polluted by agricultural runoff, including pesticides and fertilizers, chemicals used in the urban environment, landfill seepage, leaks spills and illegal dumping from industrial sources, and overflows from sewage systems. The main pollutants affecting water quality are suspended solids (TSS-total suspended solids),[54] organic material (BOD-biochemical oxygen demand),[55] toxic contaminants,[56] and nutrients.[57]

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(53) *Ibid.*

(54) Total suspended solids (TSS): This measure indicates the amount of "particulate matter" in water. Particulate matter is produced by food processing plants, pulp and paper plants, ore processing industries, domestic sewage, erosion silts and soils, and airborne particles. It is fine enough to be carried by water and may be deposited in rivers, lakes or stream beds and thus upset aquatic habitats. Toxic compounds may also adhere to the particulate matter.

(55) Biochemical oxygen demand (BOD): Effluents containing high levels of organic wastes are common to sewage treatment facilities, pulp and paper mills and food processing plants. BOD is a common measure of the oxygen-depleting potential of these organic contaminants. This figure relates to the amount of oxygen being used by microorganisms in the process of breaking down organic contaminants; the higher the organic content of the effluent, the more oxygen is used. When the rate of consumption is excessive, the available oxygen in the water system is depleted and affects fish and other aquatic life. Chemical oxygen demand (COD) is a related measure that refers to the amount of oxygen used by some inorganic compounds in the same process.

(56) Toxic contaminants: There are two types of toxic compounds, non-persistent materials and persistent materials. Non-persistent materials are those that readily break down into less harmless (oil, grease, ammonia, sulphur compounds) byproducts. Persistent compounds are highly persistent and readily absorbed by living tissue (bioaccumulate, bioconcentrate). These compounds consist of the heavy metals: chlorinated organic compounds, such as PCBs, dioxins, furans; and hydrocarbons, such as polyaromatic hydrocarbons (PAHs).

(57) Nutrients: Nutrients such as phosphorus and potassium are required for aquatic systems. Excessive quantities of these nutrients from municipal sewage and agricultural runoff stimulate growth of aquatic plants; this process is called eutrophication. Eutrophication stimulates growth of algae, which in turn die and deplete the oxygen content of the water when they decompose and thus lead to the death of fish and other aquatic life.

The most important pollutants from municipal sewage treatment facilities are those that increase the BOD of the receiving water.

The discharge of sanitary and industrial wastes to a watercourse affects the receiving system in a number of ways. Municipal water pollution decreases the aesthetic value and enjoyment of a water system, while there are numerous health risks through infection and the transmission of diseases. There is also an effect on the environment and ecology of the receiving water; the release of wastes high in organic content reduces the amount of available oxygen, rendering the water uninhabitable for fish. This effect is measured by Biochemical Oxygen Demand (BOD). Water pollution control plants (sewage treatment plants), reduce the negative environmental impact of sanitary, domestic wastes and most industrial waste waters.

A. Treating Wastewater

> The escalating cost of upgrading, maintaining and operating the existing municipal wastewater treatment infrastructure, expanding it to support residential and industrial growth, and providing a new infrastructure where it does not exist is creating a serious problem for Canadian municipalities.[58]

Domestic wastewater contains high quantities of nitrogen, phosphorus and potassium, traditional fertilizer compounds. It has been said that it takes the equivalent of 53 million barrels of oil - worth more than U.S. $1 billion - to replace nutrients yearly discarded in U.S. sewage with fossil fuel-based fertilizers.[59] The redirection, or second use, of municipal waste would utilize pollutants as valuable fertilizers. This would defy the traditional linear approach to wastewater management - use, collect, treat thoroughly then return. The benefits of an alternative - use, collect, partially treat, use again -go unrealized.[60]

Most of the wastewater from municipalities is treated to varying degrees in a sewage plant before being discharged. The quality of the returning water depends on the level

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(58) B.E. Jank, Introduction, *What's New in Wastewater Technology*, The Canadian Water and Wastewater Association, 1988, p. 1.

(59) Postel, *Last Oasis* (1992), p. 127.

(60) *Ibid.*, p. 128.

of treatment. Primary treatment involves the mechanical (physical) removal of solids by screening and settling; secondary treatment involves the biological removal of dissolved organics, by, for example, trickling filters, activated sludge and oxidation ponds; tertiary treatment involves chemical treatment to remove additional contaminants, such as nutrients, heavy metals, and inorganic dissolved solids, by precipitation, oxidation, micro-screening, inverse osmosis and coagulation-sedimentation. The effect on the receiving water depends on the municipal treatment facility. In 1989, approximately 30% of Canadians were not serviced by sewage treatment, while only 28% of Canadian's sewage underwent tertiary treatment. The organic compounds discharged in wastewater are consumed by bacteria in the receiving water. This causes a depletion of the dissolved oxygen which is essential to most aquatic life; the term used to quantify the organic concentration of wastewater is biological oxygen demand (BOD). The higher the treatment, the lower the wastewater BOD. When only primary treatment is used, the possibility of contamination by disease-carrying bacteria increases. Regardless of treatment, a large amount of chlorine and ammonia enter the receiving water.

1. Primary Treatment

Primary treatment, usually mechanical, removes the heavier particles, scum and grease from the wastewater. The quality of effluent(61) is dependent on the degree and type of contaminants carried by it. Primary treatment alone usually results in effluent of a lower quality than is achieved by complete treatment.(62) Primary treatment may remove 40-60% of the solids.

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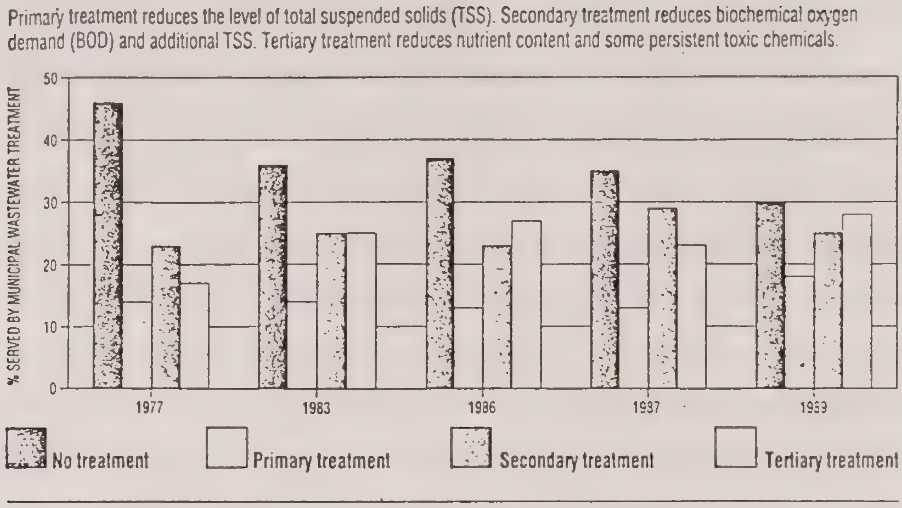
(61) Effluent is the water discharged into a receiving body.

(62) Ontario Ministry of the Environment, *Introduction to Popular Treatment Methods for Municipal Waste and Water Supplies, Process Descriptions and Flow Diagrams*, Toronto, Ontario, 1975.

Figure 6: Wastewater Treatment for Canadians



Source: Environment Canada, Municipal Water Use Database (MUD), National Inventory of Municipal Waterworks and Wastewater Systems Database (MUNDAT), in Government of Canada, *The State of Canada's Environment*, Chapter 13-12, 1991.

2. Secondary Treatment

a. Biological Systems

Biological processing is the most efficient way of removing organic matter from municipal wastewaters.[63] These systems rely on mixed microbial cultures to decompose and remove colloidal and dissolved organic substances from solutions. The treatment chamber holding the microorganisms provides the controlled environment and the wastewater provides the biological food, growth nutrients and inoculum of microorganisms.

b. Activated Sludge Treatment

Activated sludge treatment, a process that usually follows primary treatment, is a biological process that produces a high quality effluent. It removes finely divided, suspended solids and dissolved materials remaining in the wastewater. The high organic content of

(63) Mark J. Hammer, *Water and Wastewater Technology*, Second Edition, John Wiley and Sons, New York, 1986, p. 89.

municipal wastewaters is oxidized by the microorganisms which comprise the activated sludge. The organic material is metabolized into elements of CO_2 and H_2O. The biological communities of microorganisms are developed and maintained in aerated tanks and are supplied with oxygen. The amount of solids removed ranges from 90-95%.

c. Trickling Filter Treatment

The trickling filter process is carried out following primary treatment to remove the finely divided, suspended solids and dissolved materials. The filter is constructed of a bed of crushed rock or other supporting material which provides a large surface area for the development and growth of colonies of microorganisms. Aerobic bacteria build up on the support media and oxidize the organic materials in the wastewater as it is fed through it. A specially constructed underdrain tile system supports the filter media and carries off the effluent. High rate trickling filters are used in treating certain types of industrial wastes. Recirculation provides improved biological treatment.

d. Waste Stabilization Pond Treatment

Waste stabilization ponds make use of a natural purification process achieved by microorganisms in the soil and water. This process is being widely studied with the growing knowledge of the advantages and efficiency of these natural systems for reducing our waste's impact on the environment. This methodology is termed bioremediation.[(64)] In a stabilization pond, loading, depth, soil conditions and liquid losses are all controlled, together with wind action, sunlight, algae growth and oxygen. These factors provide the environment necessary for the development of the aerobic bacterial action and photosynthetic oxidation required to stabilize the wastes. In the process, microorganisms convert much of the carbon content into carbon dioxide, which, together with the dissolved nutrient and sunlight, provides conditions of growth for algae, which in turn provide a plentiful supply of oxygen for the microorganisms.

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(64) Bioremediation is the use of a natural system or living organisms to remove the polluting components of waste streams. Bioremediation is used in the treatment of municipal and industrial wastewaters to remove organic materials and other dissolved compounds. It is widely used in treated contaminated soils. It is highly efficient and may reduce the costs of pollution mitigation.

e. Anaerobic Treatment

Interest in anaerobic biotechnology for industrial wastewater treatment has greatly increased during the past decade. Today, anaerobic processes are recognized as feasible treatment for many high strength industrial wastewaters.[65] Anaerobic digestion consists of two successive processes that take place simultaneously in digesting sludge. The first stage consists of breaking down large organic compounds and converting them to organic acids along with gaseous by-products of carbon dioxide, methane and traces of hydrogen sulphide. Facultative bacteria carry out this function in a anaerobic environment to produce high concentrations of acids, so that digestion can occur. Second stage gasification converts the organic acids to methane and carbon dioxide.

3. Tertiary Treatment

Tertiary treatment removes the remaining carbon content and is also used for more recalcitrant compounds found in some wastewaters.

B. Purification of Drinking Water

In addition to treating wastewater, municipalities must also treat the water drawn from the main sources as drinking water. Conventional water purification includes chlorination, coagulation, flocculation, sedimentation and waste filtration stages. Initially these methods were thought to be adequate; today, however, there is some question as to whether the increasing concentration of toxins in the source water are being dealt with and whether these methods are effective against viruses and protozoa. Long-term exposure to chlorine and fluoride is also being studied. Studies indicate the formation of trihalomethanes following the addition of chlorine to water and suggest that water purification processes can have harmful effects. Other water

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(65) Daniel Zitomer and Richard Speece, "Sequential Environments for Enhanced Biotransformation of Aqueous Contaminants," *Environment, Science and Technology Review*, Vol. 27, No. 2, 1993, p. 227.

disinfection specialists continue to claim that, considering our present knowledge, chlorine is the safest disinfectant for health.[66]

NEW WATER MANAGEMENT

> Historically, we have approached nature's water systems with a frontier philosophy, manipulating the water cycle to whatever degree engineering know-how would permit. Now, instead of continuously reaching out for more, we must begin to look within -within our regions, our communities, our homes, ourselves - for ways to meet our needs while respecting water's life-sustaining functions.[67]

All signals point to a deterioration in the quality of fresh and marine waters unless aggressive management programs are put in place. Continued growth in global population, together with socio-economic changes, will put an increasing pressure on policy-makers and the public to find viable and realistic water strategies to deal with the following issues:

- safeguarding water to meet basic human needs;
- minimizing water loss;
- allocating scarce water for desired economic development; and
- protecting the environment from degradation and loss of its productive capacity.[68]

Water management principles have evolved and are quite well-researched; now the need for an integrated approach has become apparent. Such an approach calls for the co-operation of all levels of government and non-governmental interests. Water supplies and

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(66) As of July 1992, the Regional Municipality of Ottawa-Carleton began using chloramines instead of chlorine in its water purification plants. These chloramines are a combination of chlorine and a small amount of ammonia.

(67) Postel, *Last Oasis* (1992), p. 23.

(68) Lundqvist (1992), p. 41.

Table 2: Possible Advantages and Disadvantages of Processes Used in the Purification of Drinking Water

PROCESS	ADVANTAGES	DISADVANTAGES
Chlorine oxidation (Cl_2)	Effective disinfection. Presence of residual chlorine in water distribution systems. Oxidation of ammonium NH_4^+ (toxic) into nitrogen N_2.	Formation of haloforms and other organochlorine compounds. Leads to difficulties in biological treatment.
Ozone oxidation (O_3)	High oxidizing power. Inactivates viruses. Improves flocculation and biological treatment.	Leaves no residual to prevent the growth of bacteria in water distribution systems.
Flocculation	Removes colloidal solids from water.	Increases the problems of corrosion due to the removal of inhibiting substances and the increase in salts.
Adsorption	Improves taste and odour and removes hazardous organic products.	Removes products inhibiting corrosion.
Slow filtration through sand	Very effective in removing viruses, bacteria and organic products.	Increases concentrations of iron and manganese.

Source: W. Kühn and H. Sontheirmer, "Treatment: Improvement or Deterioration of Water Quality," *The Science of the Total Environment*, Vol. 18, April 1981, p. 219-220.

water sanitation must be handled within an overall water management scheme directed at conservation and increasing the efficiency of water consumption rather than at increasing the supply of water.

Water management must effect changes in demand, not supply. This approach is necessary as untapped sources of water are becoming rarer, and the depletion and contamination of groundwater sources are further limiting supplies. The environmental concerns about increased use of water have intensified during the last two decades to the point where development of new supplies is politically infeasible, and the prospects for financing major construction programs are discouraging.(69) The use of demand-management alternatives represents an important change in water supply planning. Demand-reduction programs can balance future supply and demand at a cost that is below the economic, social, and environmental costs of new supply development.(70)

Most of the provinces have adopted some strategies in water conservation and water efficiency.

> Doing more with less is the first and easiest step along the path toward water security. By using water more efficiently, we in effect create a new source of supply.(71)

CONCLUSION

Estimates suggest that by the year 2011 water use in Canadian municipalities will be twice that of today, if growth and consumption patterns remain the same. In purely economic terms, the case for municipal water conservation is strong. Traditionally, municipalities have taken a supply management approach to the growing demand for clean water, but such an approach costs money. As our finite resources - of which water is one - decline, we must learn

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(69) Benedykt Dziegielewski and Duane D. Baumann, "The Benefits of Managing Urban Water Demands," *Environment*, Vol. 34, No. 9, November 1992, p. 7.

(70) *Ibid.*

(71) *Ibid.*, p. 23.

to treat them with a great deal of respect. We must also learn to view water as a cycle; the less we use, the less needs to be treated in a wastewater facility and thus the lower the cost. This issue must be addressed at all levels of government in order to lessen the demand and reduce the call for an increased supply. National standards are essential and they must be enforced at the provincial level, with a user-pay, full-cost-recovery approach.

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